# GEOLOGY OF THE WILLOW CITY-ECKERT AREA
# GILLESPIE COUNTY, TEXAS

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# GILLESPIE COUNTY, TEXAS

THESIS

Presented to the Faculty of the Graduate School of
The University of Texas in Partial Fulfill-
ment of the Requirements

For the Degree of

MASTER OF ARTS

By

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ABSTRACT

This paper discloses the results of a geologic investigation of an area lying on the south rim of the Llano basin. A map is presented showing the stratigraphy and structure of this area. The historical events of the region were deformation and igneous intrusion antedating Upper Cambrian, doming in Paleozoic time, and faulting in or preceding Strawn time. The major faults trend northeast-southwest. The formations represented are the Edwards, Comanche Peak, and Basement Sands of the Cretaceous; the Cap Mountain and Hickory of Upper Cambrian age; and granites and metamorphics of pre-Cambrian age. Although stock raising and farming are the principal sources of income, the region is potentially rich in building material and minerals. An excellent climate, a sufficient annual rainfall, and a scenic panorama make this part of the "hill country" exceedingly livable.


Figure 1

Road Map of Gillespie and Surrounding Counties

The Willow City-Eckert Area is Diagonally Ruled

# INTRODUCTION

The varied geology of the Llano uplift has attracted attention since the beginning of geologic investigation in Texas; the southern border of this region, however, has been little studied. The greater part of geologic work has been done in Llano and Burnet counties and along the northern edge of the uplift. This paper deals, for the most part, with the stratigraphy and structure of the pre-Cambrian, Cambrian and lower Cretaceous beds in the vicinity of Willow City and Eckert.

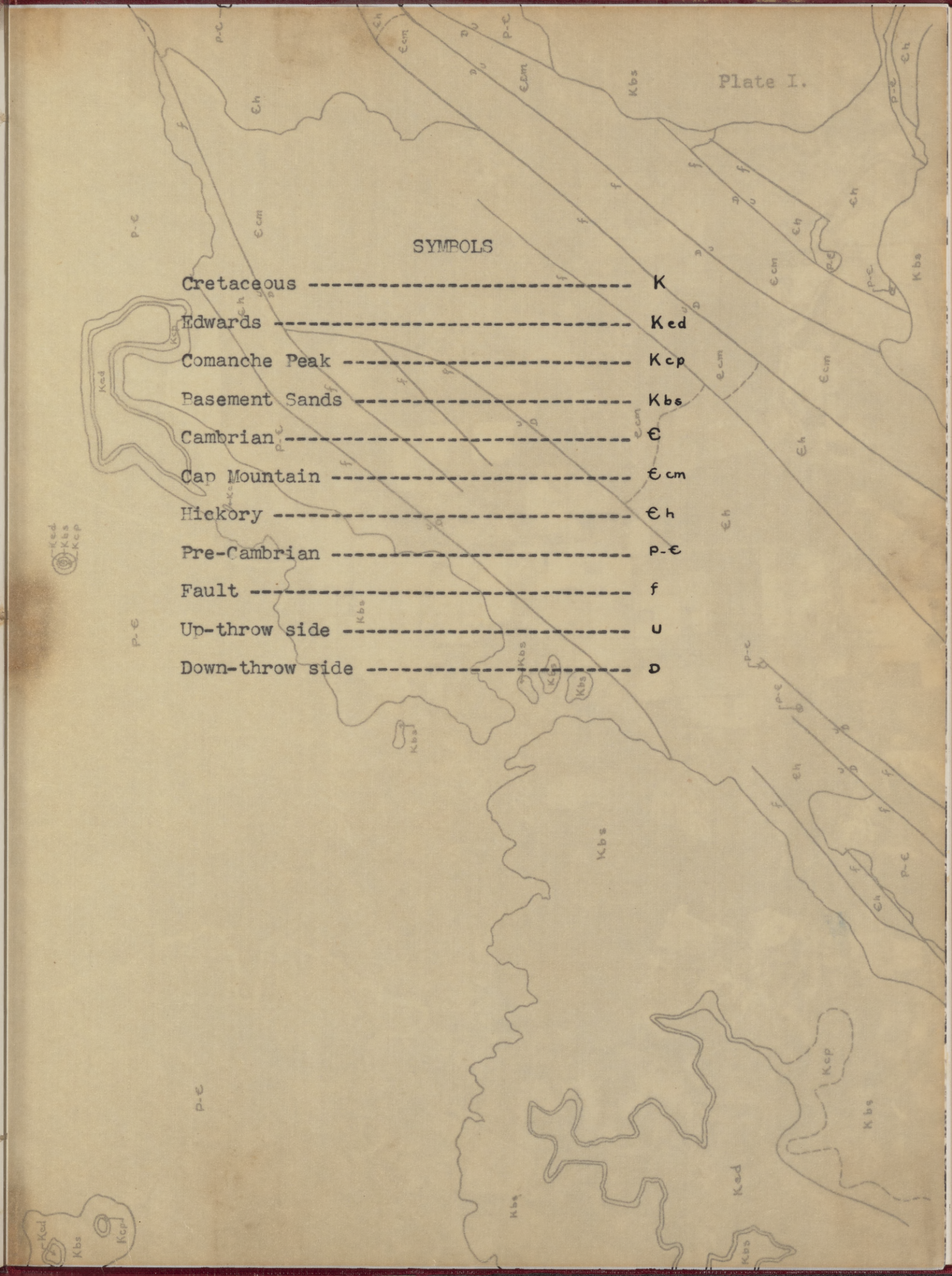
The Willow City-Eckert area lies in the northeastern part of Gillespie County and is easily accessible (see figure 1.) Eckert is about thirteen miles from Fredericksburg on the Llano road and 1.8 miles north of the southern boundary of the area (Plate II). Willow City is in the southeastern quarter and about two and one-half miles from Eckert. Willow Creek flows eastward across the southern portion, and Crabapple Creek crosses the northwest corner. The area is rectangular in outline and comprises twenty-seven square miles; it is four and one-half miles wide and six miles long.

## METHOD OF INVESTIGATION

Reconnaissance mapping was the principal method employed in this investigation. Overlapping aerial photographs of the area were obtained from the Kargl Aerial Surveys, Ltd., San Antonio, Texas. These maps were carried into the field and used as base maps. The large scale of the maps, 1"-660', made the plotting of field locations relatively simple. A study of these photographs under a stereoscope revealed structural conditions and stratigraphic breaks that might have been overlooked in the field. Many of the contacts could be traced under the instrument, requiring field reconnaissance only at widespread intervals. The sterescope was also useful in plotting the stream courses.

The use of aerial photographs in geologic mapping is shown on the following plate (Plate I); the fault trends and contacts are marked on a tracing sheet placed over the photograph.

Plate I.



SYMBOLS

| | |
|---|---|
| Cretaceous | K |
| Edwards | Ked |
| Comanche Peak | Kcp |
| Basement Sands | Kbs |
| Cambrian | € |
| Cap Mountain | €cm |
| Hickory | €h |
| Pre-Cambrian | p-€ |
| Fault | f |
| Up-throw side | U |
| Down-throw side | D |


Ked
Kbs
Kcp
p-€
€h
€cm
f
Plate I.


BOX-5-59
22
BOX-11R-58
BOX-11R-59
BOX-5-60
BOX-11R-60
BOX-5-61
BOX-11R-61
18
BOX-5-63
24
BOX-11R-62

## PREVIOUS WORK

There are many publications concerning the Llano Uplift but few of these deal with Gillespie County. Roemer[1] passed through the region between 1840 and 1850. He mentions a belt of granite rocks and Paleozoic strata surrounded by Cretaceous deposits outcropping between the Pedernales and San Saba rivers. Dr. Benjamin F. Shumard in his investigations on the uplift obtained a good outline knowledge of the geology of the region, but he was concerned chiefly with the central and northern part of the district. The occurrence of granite, with Cretaceous beds lying directly upon it, was mentioned by Buckley[2] as being found near Fredericksburg. Comstock's[3] detailed reports contain much information concerning the rocks of the region. Jones[4] made a geological investigation

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[1] Roemer, Ferdinand, "Contributions to the Geology of Texas," Am. Jour. Sci., 2, VI, 1848.

[2] Buckley, S. B., Geol. and Agri. Survey Texas (2nd Ann. Rept.), Houston, 1876.

[3] Comstock, Theodore B., "A Preliminary Report on the Geology of the Central Mineral Region of Texas," Geol. Survey Texas, 1st Ann. Rept., 1889. "Report on the Geology and Mineral Resources of the Central Mineral Region of Texas," Geol. Survey Texas, 2nd Ann. Rept., 1890.

[4] Jones, Richard A., "The Paleozoic of the Pedernales Valley in Gillespie and Blanco Counties, Texas," Univ. of Texas Bull. 2901, pp. 95-130, 1929.

along Pedernales River and contributed some information concerning the southern flank of the uplift. The state geologic map[5] published in 1937 is excellent in general but inaccurate in minor detail.

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[5] Geologic Map of Texas, United States Geol. Survey, 1937.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude for the assistance, constructive criticism and valuable counsel on matters of compilation so graciously rendered by Dr. H. P. Bybee of the Geology Department of The University of Texas. Further thanks is due to Dr. V. E. Barnes for his advice concerning field problems, for the use of his stereoscope, and for the selection of an area containing so many interesting geological problems.

## PHYSIOGRAPHY

Bell Mountain, in the northern portion of the area, is approximately 1900 feet above sea level. The lowest point in the area is in Willow Creek near Willow City, where the creek bed has an elevation of about 1660 feet.

The characteristic topography of granite in all stages of weathering (See Figures 3, 5, and 6) is found over most of the northwestern, northern, and extreme northeastern part of the area. In the northwest two Cretaceous hills capped with Edwards limestone rise to a considerable elevation above the surrounding pre-Cambrian rocks. In the north-central portion Mount Nebo and Bell Mountain are topographically-high Cretaceous remnants, also capped with Edwards. The southwestern portion is crossed by a range of Cretaceous hills; a long arm of basal Cretaceous sands and conglomerates extends northeastward from this range of hills and comes within a few hundred yards of a similar arm extending southwestward from Bell Mountain. A fringe of basal Cretaceous sediments covers the southeastern corner in the Willow City vicinity. The farming lands extend through the central portion and are more or less confined to the Hickory and basal Cretaceous sands. Topographically this is a wide valley drained by many small streams. In the northeastern portion a Cap Mountain escarpment bordering

a flat Hickory valley (See Figure 10) forms the eastern front of a relatively featureless high plain that extends southwestward almost to Eckert. This plateau is the topographic expression of a Cap Mountain graben now standing higher than the adjacent, less resistant Hickory sandstone. This northeastern portion is in the southern part of the region known locally as "Hell's Half Acre."

Motts of live oak, producing a banded pattern on an aerial photograph, are the most characteristic trees found on the Edwards hills. A thick growth of Texas oak marks the Comanche Peak outcrop. The basal sandy phase of the Cretaceous forms rich soil and supports good farms and orchards. Where this formation has not been cultivated, post oak trees abound. Cedar trees are scattered over the entire area but are more common on the limy Cretaceous hills. The conglomerate at the base of the Cretaceous (See Figure 14) is marked by a strip of live oak motts. The base of the Cap Mountain is covered with a dense growth of trees, largely live oak. The Hickory, where not under cultivation, supports the usual vegetation common to sandy land, the post oak being the most characteristic tree. Mesquite trees are largely confined to the pre-Cambrian formations (See Figure 4); oak trees are numerous in the granite areas. The Cap Mountain and

pre-Cambrian formations are largely devoted to pasture lands. Locally the granite lands are considered the best for cattle raising. The Cretaceous hills make ideal sheep and goat ranges.

The best exposures are found along the creeks and on the steep hillsides. Where the Hickory formation is cut by faults, the sandstones have been slightly metamorphosed, forming ridges of quartzite (Figure 9 ). These ridges greatly facilitate the tracing of fault trends.

The annual rainfall at Fredericksburg[6], taken over a period from 1873 to 1912, averaged 27.78 inches. The months receiving the most rainfall over this period were April and May, averaging 3.38 and 3.65 inches, respectively. January, with the least rainfall, averaged 1.31 inches during this time.

The streams in the vicinity are intermittent and often sand and gravel logged. Except in times of extended drought, however, the streams contain many small pools fed by numerous springs. In Willow and Crabapple creeks these pools are often several feet in depth and quite extensive. Small game fish are plentiful and lure many summer sportsmen to the region.

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[6]Kocher, A. E., "Reconnaissance Soil Survey of South-Central Texas," U. S. Dept. of Agriculture, Bureau of Soil, p. 20, 1915.

## STRATIGRAPHY

Rocks ranging in age from Lower Cretaceous to pre-Cambrian are exposed in the area (See Figure 2). The formations included are as follows:

Lower Cretaceous (Comanche)

Fredericksburg

Edwards

Comanche Peak

Trinity

Basement Sands

Cambrian

Cap Mountain

Hickory

Pre-Cambrian

GENERALIZED COLUMNAR SECTION

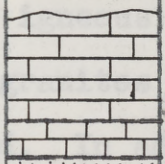
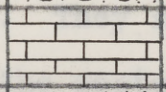
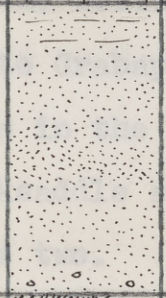
| SYSTEM | SERIES | FORMATION | SECTION | THICKNESS | CHARACTERISTICS |
|---|---|---|---|---|---|
| CRETACEOUS | COMANCHE | Edwards |  | 100' | Massive, flint-bearing limestone |
| | | Comanche Pk. | | 20' | Sandy limestone |
| | | Basement Sands | | 200' | Limy near top<br>Red sand<br>Basal conglomerate |
| CAMBRIAN | U. CAMBRIAN | Cap Mountain |  | 80' | Glauconitic limestone |
| | | Hickory |  | 300' | Limy near top<br>Cross-bedded sandstone often red<br>Coarse material near bottom |
| PRE-CAMBRIAN | LLANO | Metamorphics |  | | Schist and gneiss intruded by igneous material |
| | | Intrusives | | | Mainly pink granite but the more basic intrusives not uncommon |

Figure 2

Generalized Columnar Section Giving Approximate Thickness of the Formations in the Willow City-Eckert Area.

## PRE-CAMBRIAN

The pre-Cambrian sediments of the region were extensively intruded by igneous material. The majority of these intrusives are granites varying in texture from coarse to fine-grained. In addition to the granite there are smaller intrusives of more basic rocks. The sedimentary rocks of pre-Cambrian age have been greatly altered by metamorphism. They are exposed in the vicinity of Mount Nebo and in the western part of the area along the road from Eckert to Crabapple. Paige[7] refers to the pre-Cambrian sediments in the Llano region as Valley Spring gneiss and Packsaddle schist, the Valley Spring being the older of the two. The scattered exposures in the Willow City-Eckert area, although recognizable as pre-Cambrian metamorphics, were not mapped as separate units.

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[7] Paige, Sidney, Llano-Burnet Folio, Geologic Atlas of the United States. U. S. Geol. Surv., 1912.


Figure 3

Topography Typical of the Granite Region


Figure 4

Mesquite Covered Pre-Cambrian Near Mt. Nebo


Figure 5

Weathering in Jointed Granite


Figure 6

Good Cattle Country

## CAMBRIAN

No lower or middle Cambrian deposits have been recognized in Texas.[8] The upper Cambrian, however, is well developed in the Llano region. In the Willow City-Eckert area the upper Cambrian is represented by the Hickory and Cap Mountain formations.

### Hickory Formation

The term Hickory was first applied by Comstock[9] to a series of beds in the valley of Hickory Creek and its tributaries in Llano County. The thickness of the Hickory in the Llano region is from a thin stratum to 350 feet[10]. The formation is well developed in the Willow City-Eckert area, but it is so highly faulted that an accurate measurement of its thickness could not be obtained.

The first few inches of the basal portion contain some coarse material, angular quartz fragments as large as half an inch in diameter, followed by several feet of coarse,

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[8] Sellards, Adkins and Plummer, Geol. of Tex. Bull. 3232.

[9] Comstock, T. B., "A Preliminary Report on the Geology of the Central Mineral Region of Texas," Geol. Surv. Texas 1st Ann. Rept., 1889.

[10] Paige, Sidney, Llano-Burnet Folio, Geologic Atlas of the United States, U. S. Geol. Survey, 1912.

Figure 7

A Hickory Hill

Figure 8

A Typical Hickory Exposure on Willow Creek


Figure 9

A Quartzite Ridge Along a Hickory Fault


Figure 10

Hickory Flat with the Cap Mountain Escarpment

in the Background

cleanly washed sand in a fine grained sandstone. This basal portion is overlain by sandstone, commonly cross-bedded and often exhibiting ripple marks of various sizes. In places this is colored deep red or brown by a coating of iron oxide. The Hickory sandstone, where not displaced by faulting, occupies the base of the Paleozoics. It grades upward into the overlying glauconitic sands and limestones of the Cap Mountain formation without a well marked litho-logic break.

Cap Mountain Formation

This formation was named by Paige and applied to the beds exposed on Cap Mountain, in Llano County, where the entire thickness is displayed. As previously stated, its base is not sharply defined and it is determined by the lowermost predominantly calcareous beds. The formation grades from the lower sandy limestone to fairly pure lime-stone. The limestone is well bedded, in places flaggy, bluish or grayish, and mottled by impure streaks of brown sandy material. Some of the strata consist very largely of trilobite fragments. Although a complete carapace is seldom found, the abundance of the fragments indicates a sea teeming with trilobite life. The glauconite, so abund-ant in this formation, is closely associated with the abundance of organic matter.


Figure 11

The Cap Mountain Escarpment Rising Above the Hickory


Figure 12

Blocks of Indurated Sandstone Along a Hickory Fault


Figure 13

The Broken Line Indicates the Hickory-Cap Mountain Contact (note density of vegetation)


Figure 14

Live Oak Growing on the Cretaceous Conglomerate

Normally, the formation lies immediately above the Hickory sandstone and has much the same distribution over the Llano region. Its area of outcrop, however, is generally narrower than the sandstone which often spreads as a thin veneer over considerable territory. The upper beds of the formation, including the Lion Mountain member, are not exposed in the Willow City-Eckert area.

## CRETACEOUS

One of the most striking features exhibited in this area is the marked unconformity at the base of the Cretaceous system. The progressive encroachment of the sea over an eroded region is remarkably portrayed. The formations of this age represented in the Willow City-Eckert area are, in their order of deposition, the Basement Sands, the Comanche Peak, and the Edwards.

### Basement Sands

The term "Basement Sands" is applied by Hill[11] to the basal Cretaceous sands and conglomerates deposited in this region at the time upper Glen Rose and Walnut limestones were being deposited to the east. The lower portion of the formation consists of a conglomerate composed of Paleozoic and pre-Cambrian fragments measuring from a few inches to a foot or more in diameter. The upper part is a sand ordinarily red or buff in color. The top of the formation is a buff colored sand just below the nodular Comanche Peak lime. The sand series has a thickness of about 200 feet in the southwestern portion and thins northward to about 35 feet in the Bell Mountain vicinity. This variation in thickness is due to the progressive overlap of the Cretaceous

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[11] Hill, R. T., "Geography and Geology of the Black and Grand Prairies," U. S. Geol. Survey, 21st Ann. Rept., Pt. 7.


Figure 15

View of Mount Nebo from the Llano Road


Figure 16

The Basal Cretaceous Conglomerate Resting on

Pre-Cambrian Arkose

sea upon the Llano uplift. In restricted areas in Gillespie County, granite knobs protruded above the ancient Paleozoic land surface and were not covered by Cretaceous seas until Fredericksburg time. The encroachment of the sea at this time, however, was so rapid that the sandy phase was omitted and limestone was deposited directly upon the granite.

Comanche Peak

The Comanche Peak was named by Shumard[12] in 1860. The type locality of this formation is at Comanche Peak in central Hood County. In the Willow City-Eckert locality both the upper and lower contacts appear to be concordant. The basal part of the formation is a nodular, sandy lime occurring immediately above the buff colored Basement Sands. The middle portion consists of massive sandy limestone represented topographically by a vertical ledge about 12 feet in thickness near the crest of the hillsides. The top of the formation is a nodular limestone just below the flaggy flint-bearing limestone marking the base of the Edwards. The formation is about 20 feet thick in the area.

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12 Shumard, B. F., "Observations Upon the Cretaceous Strata of Texas," Academy of Sci. of St. Louis, Transactions, Vol. 1, pp. 583-585, 1860.

Edwards

The Edwards is the youngest Cretaceous formation found in the area. It was named by Hill and Vaughan[13] in 1897, and the type locality is on Barton Creek near Austin. The Edwards consists of persistent strata of even-bedded and medium-to-massive limestone. Flint is abundantly present in nodules and in thin strata. The greatest thickness found in the area was about 75 feet.

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13 Hill, R. T., and Vaughan, T. W., "Geology of the Edwards Plateau and Rio Grande Plain Adjacent to Austin and San Antonio, Texas, with Reference to the Occurrence of Underground Waters," U. S. Geol. Survey, 18th Ann. Rept., Pt. 2, 1897.

## STRUCTURE

The Llano uplift includes all of Llano County and part of Brown, Mason, McCulloch, San Saba, Lampasas, Blanco, Gillespie, and Kimble counties. Structurally the region is a dome, bringing the pre-Cambrian more than 1000 feet above sea level, the total doming being 5000 to 6000 feet.[14] The formations exposed in the center of the dome are of pre-Cambrian age, these older rocks being surrounded by formations of Paleozoic and Cretaceous ages. The structural history of this region includes deformation antedating the Upper Cambrian, doming in Paleozoic time, and faulting in or preceding Strawn time. In addition to the structural deformation of these periods the region has undergone repeated fluctuations in elevation in Paleozoic and Mesozoic time as shown by the several incursions of the sea across this region. Extensive faulting occurred in the region in post-Bend time. There is much local variation, but the trend of these faults is on the average northeast-southwest.[15] (See Figure 17).

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[14] Sellards, E. H., Adkins, W. S., and Plummer, F. B., "The Geology of Texas," Univ. of Texas Bull. 3232, Vol. 1, 1932.

[15] Sellards, E. H., and Baker, C. L., "The Geology of Texas," Univ. of Texas Bull. 3401, Vol. 11, 1934.

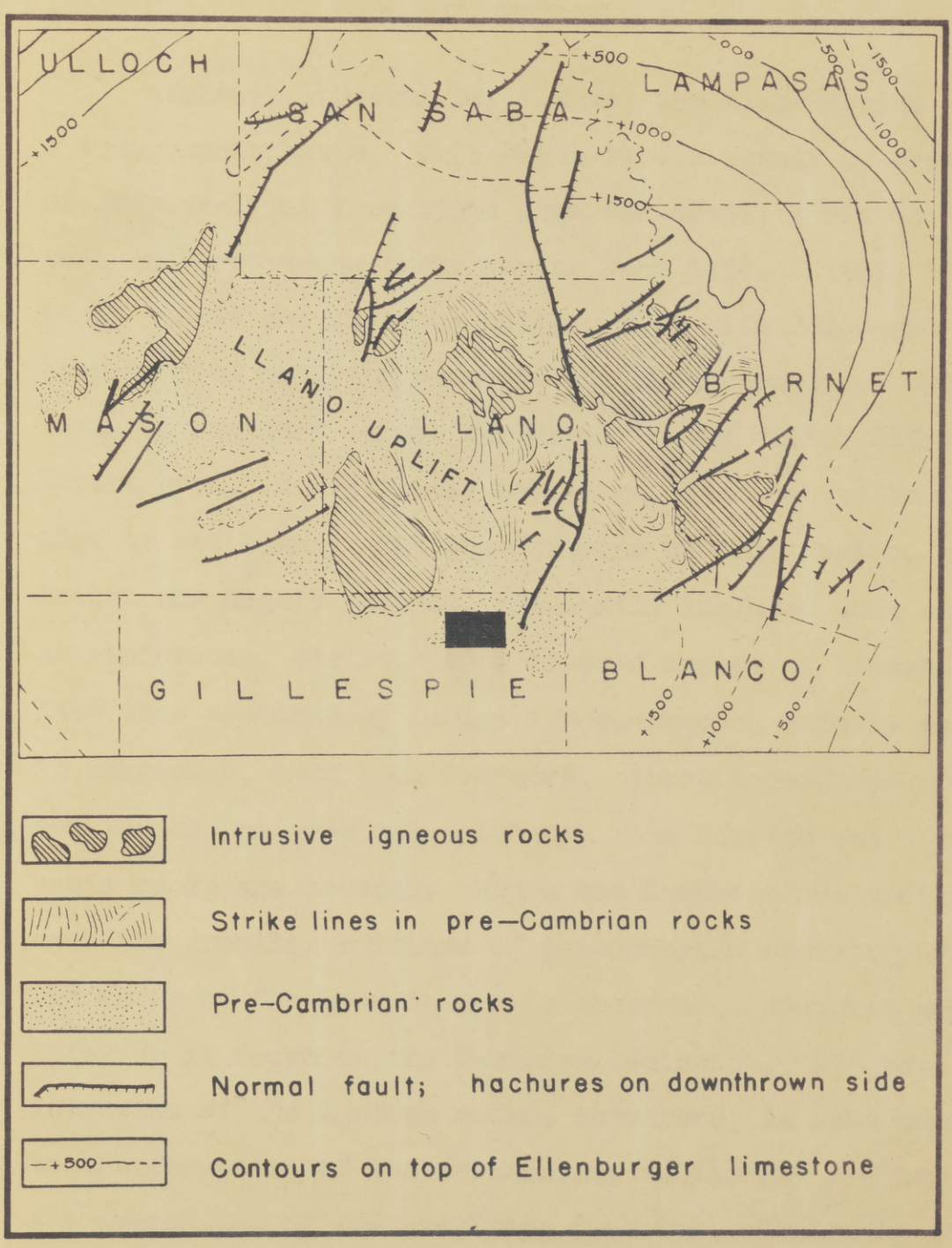


Figure 17

The Major Structural Trends of the Llano Uplift

The Willow City-Eckert Area is Shown in Black

## GEOLOGIC HISTORY

Although structurally a dome, the Llano region is now a topographic basin. This basin is the result of erosion of the overlying formations from the crest, a rim of Paleozoic and Cretaceous rocks having been left. Within the basin itself are numerous hills capped with Paleozoic rocks representing outlying remnants of these formations which formerly extended across the dome.[16] The Willow City-Eckert area, as previously mentioned, lies on the southern edge of the basin. The pre-Cambrian of this region, although now highly altered, originally included such sediments as sandstones, shales, and a limited amount of limestone. Into this sedimentary series igneous rocks, chiefly acidic in character, have been intruded. These intrusives appear now largely as granites, although some diorite and other basic rocks are present. Where the Cambrian rests directly upon the granite, evidence of pre-Cambrian disintegration and decay of the granite may be observed. Reworked granite likewise is found in the Cambrian sediments. The time of intrusion of the igneous rocks, therefore, is subsequent to the formation of the sedimentary series but previous to the deposition of the overlying Cambrian. Following the

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[16] Sellards, E. H., Adkins, W. S., and Plummer, F. B., "The Geology of Texas," Univ. of Texas Bull. 3232, vol. 1, 1932.

intrusion of the igneous rocks, the region was subjected to pronounced folding. Afterwards a period of extensive erosion removed the uppermost rocks, leveled off the folds, and exposed the granite. Upon these exposed granites and truncated folds the Cambrian sediments were deposited. Since the overlying sediments are of upper Cambrian age, it is possible that this interval of erosion may have been largely or entirely within Cambrian time.

There is no evidence of a lower or middle Cambrian sea in the Texas region, the oldest Paleozoic deposits known being of upper Cambrian age. The upper Cambrian sea transgressed a land of considerable topographic relief, granite knobs, in particular, rising above the general land level. In this respect the Willow City-Eckert area is in no way different from the surrounding country. There is no evidence that the Llano region had been domed at this time.[17]

Before the encroachment of the Cretaceous seas, the doming and faulting of the Llano region had been accomplished and the whole region extensively eroded. The Willow City-Eckert region affords an excellent example of the extent of this erosion, all the formations younger than the

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[17] Sellards, E. H., and Baker, C. L., "The Geology of Texas," Univ. of Texas Bull. 3401, Vol. II, 1934.

Cap Mountain having been stripped off before Cretaceous time. An idea of the slope of this old land surface may be gained by comparing the elevations of the basal Cretaceous-pre-Cambrian contact at two localities in the area. At Willow City the elevation of the contact is about 170 feet below the contact at Bell Mountain four miles to the north. It should be apparent that in ascending this slope the Basement Sands traversed diagonally a vertical column of the Cretaceous formations, representing a long period of time. As the Comanche ocean advanced from the southeast over the ancient land of this region, basal sands and conglomerates were laid down at the edge of the forward moving seas. Thus, we find these sands and conglomerates being deposited in the Willow City-Eckert area as late as early Comanche Peak time. The Comanche Peak, where recognizable as such, is very sandy in this vicinity. The Edwards formation is represented in its normal facies, indicating a complete submergence by this time.

## ECONOMIC RESOURCES

The pre-Cambrian of the region contains a variety of minerals, and much prospecting has been done in the area but no commercial deposits have been developed. The granites of the region, of which there are several varieties, could be used for building purposes or monumental work.

The upper Cambrian formations of the region in their underground extension are important water-bearing formations. The Hickory sandstone in particular supplies an abundance of water to wells. Much information concerning the depth of water wells, the chemical content of the water, the use, and the producing formations may be obtained from a water survey made by Shields.[18] Although many of the wells produce from granite, the wells drilled into the Hickory sand are the most productive. The depth of the wells ranges from 44 feet to 169 feet. The dissolved solid content is approximately 300 parts per million; one well, however, has a solid content of 3,691 and is used only for stock. The water is used for domestic purposes, stock watering, and irrigation.

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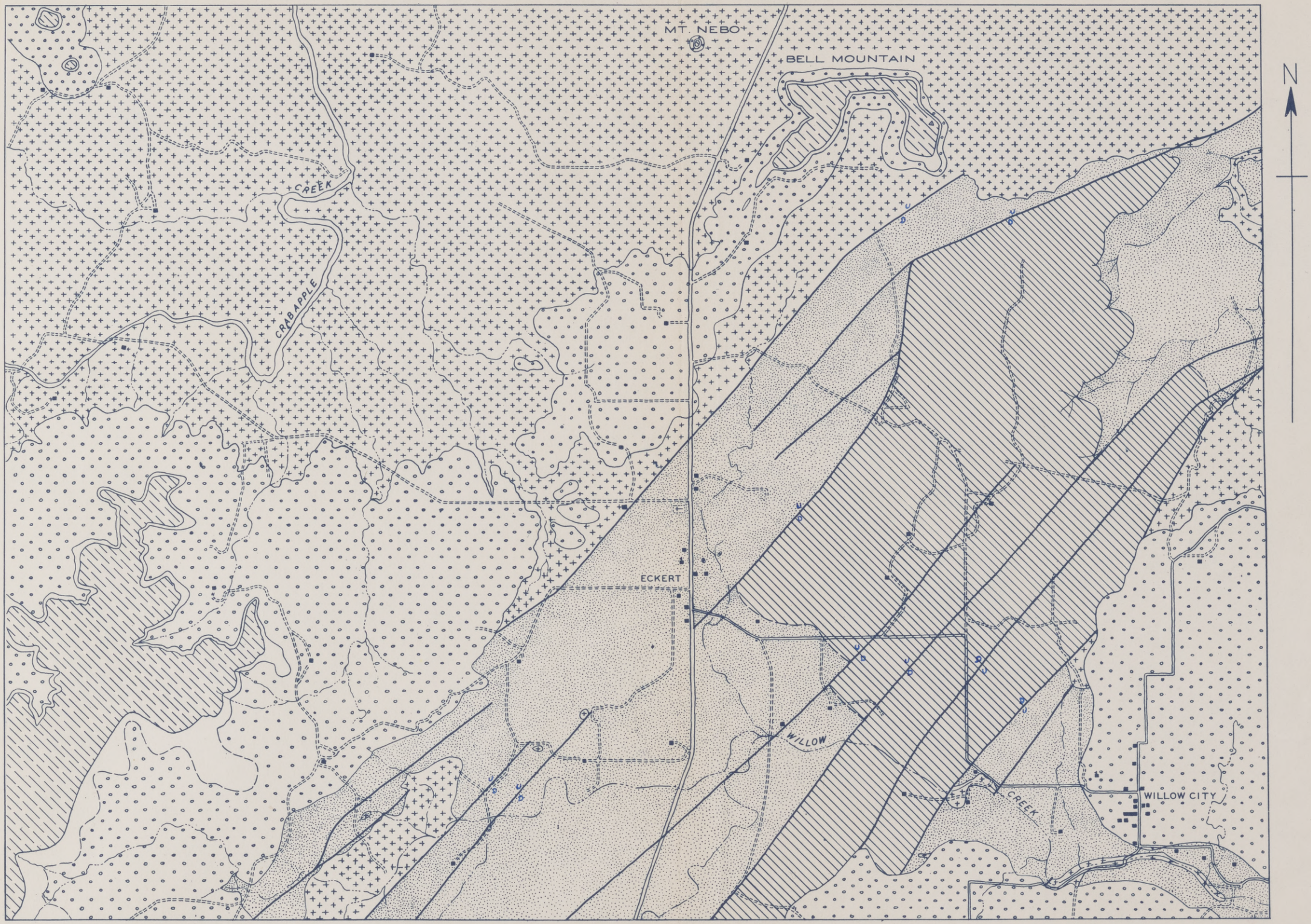
[18] Shields, Elgean, "Gillespie County, Texas," Works Progress Administration Ground-Water Survey, Project 2088, 1937.

The valleys, where soil conservation has been practiced, are rich agricultural areas. Most of the farms are devoted to small grain crops, such as wheat and oats. Stock raising is of considerable importance, cattle, sheep and goats seeming to fare equally well.

# GEOLOGIC MAP OF THE WILLOW CITY - ECKERT AREA

## GILLESPIE COUNTY, TEXAS




EDWARDS

COMANCHE PEAK

BASEMENT SANDS

0 1/4 1/2 3/4 1

ONE MILE

CAP MOUNTAIN

HICKORY

PRE-CAMBRIAN

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